

WEST AFRICAN CACAO RESEARCH INSTITUTE



ANNUAL REPORT

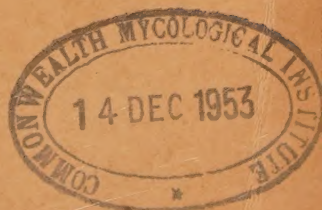
April, 1952 to March, 1953

TAFO, GOLD COAST

Published on behalf of the West African Cacao Research Institute by the
Crown Agents for the Colonies, 4, Millbank, London, S.W.1.

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Price 5/-



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WEST AFRICAN CACAO RESEARCH INSTITUTE.

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WEST AFRICAN CACAO RESEARCH INSTITUTE.

SENIOR STAFF LIST AT 31ST MARCH, 1953.

Director	...	...	J. WEST, B.S.A., A.I.C.T.A.
Deputy Director	...		A. PICKLES, M.Sc., A.I.C.T.A.
Division of Entomology			J. NICOL, B.Sc.(For.). R. G. DONALD, B.Sc., A.I.C.T.A. H. R. MAPOTHER, B.A., B.Sc., A.R.I.C. P. B. CORNWELL, M.Sc., A.R.C.S., D.I.C., D.T.A. D. J. TAYLOR, B.Sc. F. E. DECKER.
Division of Pathology	...		T. W. TINSLEY, B.Sc., Ph.D. A. L. WHARTON, B.Sc., D.A.S., D.T.A. R. M. LISTER, B.Sc., D.A.S., D.T.A.
Division of Botany	...		J. F. ARCHIBALD, B.Sc.(Hort.), F.R.H.S. H. H. ROGERS, B.Sc., Dip.Agr.Sc. R. KNIGHT, B.Sc., Dip.Agr.Sc.
Division of Soil Science and Chemistry.			J. A. R. MACLEAN, B.Sc., Ph.D. S. N. ADAMS, B.A., D.Phil.
Division of Agronomy			R. J. BENSTEAD, N.D.A., C.D.A. R. WICKENS, B.A., D.T.A.
Maintenance Engineer			C. ALDERSON, D.S.O., E.D., B.Sc., M.Inst.M. and C.E.
Secretary	...	...	G. H. NEAL, F.I.A.C., F.R.S.A., F.C.T.C.

I. POLICY AND ORGANIZATION.

SENIOR STAFF CHANGES.

It is encouraging to report that the position regarding appointments to the Senior Staff is improving. Mr. A. L. Wharton assumed duty as Plant Pathologist and Messrs. P. B. Cornwell and R. M. Lister as Entomologists. Mr. D. J. Taylor was appointed Entomologist but he remained in Trinidad for special duty for about six months after completing his post-graduate training.

MANAGING COMMITTEE.

The Managing Committee met at Tafo in November, 1952, and at Ibadan in March, 1953. The full meetings were preceded by meetings of the Technical Sub-Committee.

As a result of these additional appointments to the Senior Staff it was possible to draw up plans for the implementation of the scheme for expanding cacao research in Nigeria, leading to the establishment of a W.A.C.R.I. Sub-Station in that territory.

As a first step Mr. R. G. Donald, Entomologist, was posted to Ibadan in March, 1953, to complete a survey of the cacao mealybugs with their attendant ants, predators and parasites.

TOURS.

Mr. Pickles visited Nigeria in November, 1952.

Dr. Tinsley, Virologist, and Mr. Knight, Plant Breeder, visited Nigeria and the British Cameroons in October, and Dr. Tinsley also paid visits to the French Ivory Coast in December, 1952, and to Sierra Leone in February-March, 1953.

VISITORS.

In June, 1952, His Excellency the Governor of the Gold Coast and the Right Honourable Oliver Lyttelton, Secretary of State for the Colonies, visited the Institute, accompanied by a party including the Minister for Agriculture and Natural Resources.

In July, 1952, two parties of delegates to the West African Inter-Territorial Conference visited the Institute. The parties included His Excellency the Governor of Nigeria and delegates from Nigeria, the Gold Coast, Sierra Leone and the Gambia.

The Chairman and representatives of the United Nations Visiting Mission to West Africa paid a short visit in August.

The Chairman and members of the Gold Coast Cocoa Marketing Board spent a day at the Institute in February, 1953.

The Institute has welcomed numerous visitors, including scientists and planters, from other parts of Africa, Europe and North America.

Collaboration has been maintained with the Agricultural Departments of the Gold Coast, Nigeria and, more recently, Sierra Leone.

Two parties of farmers, teachers and others from Nigeria visited the Institute in September, 1952. They were accompanied by officers of the Nigerian Agricultural Department. These visits, which now take place annually, are welcomed as a means of keeping those concerned with cacao production in Nigeria acquainted with the work of the Institute.

The Gold Coast Agricultural Department has continued to organize visits by farmers, teachers and students, to the Institute almost daily.

SCIENTIFIC ASSISTANCE.

The Institute continues to receive most welcome and valuable assistance from individuals and research organizations. Collaboration with staff of the University College of the Gold Coast has led to the development of a radio-active tracer technique for the study of the feeding habits and movements of mealybugs. The Commonwealth Bureau of Biological Control has continued to supply the Institute with parasites of mealybugs for test and for mass release in the field. The British and American Cocoa Panels of the cocoa manufacturers continue to receive samples of cacao beans for assessment of quality in the attempt to discover a satisfactory method of fermenting small samples. This is of vital importance in assisting the Plant Breeders in the direction of their breeding and selection programmes. Valuable assistance has been received from the scientists at Rothamsted on the statistical lay-out and analysis of experiments and on virus research.

RESEARCH ON SYSTEMIC INSECTICIDES.

The Institute has continued its own research on the effectiveness of various systemic insecticides against cacao mealybugs, and a satisfactory technique has been developed for preliminary screening tests.

In addition a great deal of time has been devoted to experiments in co-operation with Messrs. Pest Control Limited on methods of applying the systemic insecticide Hanane to cacao trees in the field.

ACKNOWLEDGMENTS.

As in previous Annual Reports the technical parts of this Report which follow have been prepared by the research officers concerned, and the Director gratefully acknowledges their authorships.

II. VIRUS RESEARCH.

STRAINS OF THE CACAO SWOLLEN SHOOT VIRUS (CSSV).

The W.A.C.R.I. collection of strains of CSSV has been greatly increased by the addition of new material from the cacao areas throughout the Gold Coast. The symptoms of these strains in young cacao seedlings are being recorded in detail. It is hoped that these data together with immunological records will be useful in the classification of strains.

Attempts to transmit the Asalu (Nigeria) strain by mealybugs were again unsuccessful though it is easily transferred by graft inoculations. It is of interest to record another strain which appears not to be insect transmitted. This was found in an outbreak at Eddu Suaso, four miles north of Half Assini and three miles south of the Ivory Coast—Gold Coast border. Unlike other Western Province strains—no swellings are produced and the initial symptoms are often followed by several symptomless flushes. It is easily transmitted by grafting.

A new series of cross-protection tests has been started, grouping the strains into the following geographical areas: (1) Gold Coast—(a) Western Province, (b) Ashanti, (c) Eastern Province and (d) Togoland; (2) Ivory Coast and (3) Western Nigeria. Representative strains have been selected from these areas for further study. Preliminary experiments with some Nigerian strains have demonstrated that Offa Igbo I and II, Olanla I and II and Ilesha are not related to Alaparun. Asalu is not related to the Ilesha group.

Other tests with the Eastern Province group have confirmed that the mild strain of New Juaben is related to the severe strain of New Juaben and Dawa but not to Kpeve, Mampong or Bisa. With the Ashanti group Konongo is not related to Bosumtwi.

T. W. TINSLEY.

HOST RANGE OF CSSV.

No new susceptible hosts have been recorded although many species in the order Tiliales are still under test. Through the kind offices of the Forestry Department, Gold Coast, seeds of several species of the Sterculiaceae, previously not available, have been supplied. It is hoped that eventually all species related to *Theobroma cacao* occurring in the Gold Coast and, if possible in Western Nigeria, will be tested for susceptibility to CSSV.

All the species previously recorded as being susceptible are being retested with eight quite dissimilar strains to obtain further evidence of differential susceptibility.

Both *Cola togoensis* Engl. and Krause and *Pachira oleagina* Decne (= *Pachira insignis* L.?) show very clear symptoms of CSSV after infection, but so far it has not been possible to obtain positive

back-tests. The testing of the susceptibility of other species of *Theobroma* has continued. *Theobroma grandiflorum* K. Schum. and *Theobroma speciosum*? can be infected with several of the virus strains.

No further natural infections in wild hosts have been recorded other than in *Cola chlamydantha* K. Schum. A third survey has been made of this species and the presence of infection established in the Foso district. This is the furthest station east that this has been recorded.

T. W. TINSLEY.

W.A.C.R.I. HERBARIUM.

The Herbarium has been reorganised preparatory to starting new collections.

All species collected for testing as possible new hosts of CSSV will be sent for confirmation by National Herbaria, in addition to the authentic identifications of previously recorded hosts.

Lists of members of the Tiliales required for testing were compiled for distribution. The Botany Department, University College of the Gold Coast, the Departments of Forestry and Agriculture, Gold Coast, have given valuable assistance in supplying seed from these lists.

T. W. TINSLEY.

A. L. WHARTON.

ENVIRONMENTAL STUDIES.

The effect of light intensity on the symptom expressions of one strain of CSSV has been studied in young cacao seedlings. Twenty plants were infected and grown under a dark cage for about three months, a similar number was maintained outside as a control. Records were taken every two weeks of the symptoms shown by each leaf, the dimensions of leaves, girth, height and internode length of the stems. The daily maximum and minimum temperatures were recorded inside and outside the cage.

The results of this first experiment indicated that the symptoms produced in plants grown under heavy shade were much milder than those produced in the controls, though the number of leaves was smaller. This work is to be continued on a larger scale.

T. W. TINSLEY.

A. L. WHARTON.

MECHANICAL TRANSMISSION.

Extracts from various parts of young infected cacao seedlings, leaves, stems, roots, spent cotyledons, obtained by grinding or homogenising with and without a phosphate buffer (pH 7.0) and sodium sulphite, have been used for inoculations. No transmissions were recorded.

The supernatant fluid obtained after centrifugation of a mixture of homogenised roots infected with the severe strain of New Juaben, and an equal weight of pH 7.0 phosphate buffer was used for injection into seedlings via cut leaf-stalks. No transmissions resulted.

In an attempt to find if substances present in the cacao plant might exercise an inhibiting or inactivating effect on viruses a series of experiments were started to investigate the action of various cacao extracts on the infectivity of tobacco mosaic virus in *Nicotiana glutinosa* L.

The strain of TMV used was isolated from locally grown tobacco and after inoculation to *N. tabacum* L. var. White Burley, the virus was purified by a usual method. TMV produces water-soaked local lesions in *N. glutinosa* under the climatic conditions prevailing at Tafo. Results so far indicate that cacao stem mucilage, leaf extracts and fresh and spent bean extracts all decrease the number of local lesions produced by TMV.

R. M. LISTER.

T. W. TINSLEY.

TRANSMISSION BY *Pseudococcus njalensis* LAING.

The transmission rates of CSSV by the above mealybug are extremely variable, particularly when only few or single insects are used. It was, therefore, necessary to perfect a method of determining with certainty whether or not mealybugs have fed on the source plants. Work done at W.A.C.R.I. with the collaboration of the Department of Physics, University College of the Gold Coast, promises to provide such a method. Radio-active phosphorus in the form of orthophosphoric acid was used. Results so far show that some of the individuals of *P. njalensis* which apparently settled on the source plants did not pick up radio-active phosphorus from them and this may indicate that they did not feed.

The testing of colonies of *P. njalensis* reared from single individuals has not so far provided any evidence that there are non-transmitting strains of this species.

PERSISTENCE OF VIRUS IN STARVED VECTOR.

Experiments are being done to find how long CSSV (Strain New Juaben) will persist in *P. njalensis* starved under laboratory conditions. So far virus transmission has been obtained from adults starved for up to 49 hours, and from 1st instar nymphs starved up to 24 hours. Experiments with other instars await the development of a method of identifying these in life with certainty.

SEARCH FOR NEW VECTORS.

The two new Pseudococcid vectors reported in the last Quarterly Report, H6756 and H6817, have been identified as *Pseudococcus* sp. nr. *gahani* Green and *Pseudococcus* sp. close to *P. proteae* Hall,

respectively.* The former is the same species as that reported as a vector by Posnette, 1950. (Ann. Appl. Biol. 37, p. 381.)

Mesohomotoma tessmanii Aulm. and *Toxoptera coffeae* Nietner have again failed to transmit CSSV in both long and short infection feeding time experiments. An experiment has been started to find if the alate forms of *T. coffeae* can transmit the virus.

ARTIFICIAL FEEDING OF VECTORS.

Extracts of infected leaves, stems and roots were incorporated into an agar medium and individuals of *Pseudococcus njalensis* Laing, allowed to feed on it for 24 hours. Equal volumes of undiluted sap and 4 per cent. agar were used, and the constituents mixed whilst the agar temperature was at 60° C. A few seconds afterwards, the temperature of the mixtures was about 40° C. and these were then poured into petri dishes and cooled rapidly till set. Settling of the insects was improved by cutting troughs in the agar with a needle.

There was no transmission of virus when the insects used were allowed to feed subsequently on cacao beans.

R. M. LISTER.

*We are indebted to Dr. W. J. Hall for these identifications.

III. CAPSID RESEARCH.

INSECTICIDE TRIAL AREA.

This area of young Amelonado cacao planted as seed at stake in February, 1947, continues to serve as a most valuable area for entomological experiments. Growth on the whole has been remarkably good and a considerable harvest of pods was obtained this year (*i.e.*, six years from planting). The area is divided up into 36 one-sixth acre plots and the harvest from these was variable, but from the best plot a yield approximating to seven loads (420 lb.) of dried cacao per acre was obtained. The extension to this area planted in June, 1950, has grown well after a bad start due to the effects of the first dry season and several of the more vigorous seedlings flowered during the latter part of the year.

REGENERATION OF CAPSID POCKETS—OLD STATION.

The coppiced plots on the Old Station continue to grow well and there seems to be no doubt that this is a sound method of regenerating well defined capsid "pockets". These "pockets" are the result of continuous and severe capsid damage and if left to themselves they rarely recover. Application of chemical insecticides is expensive and the resulting growth tends to be fastigate due to the development of chupon growth. Such growth on old trees seldom results in well-shaped, healthy cocoa trees.

When the trees in a capsid " pocket " are coppiced at four to six inches from the ground vigorous chupons develop from the base and they rapidly send down new roots and become established. Flowers and pods are frequently produced in the second year and a reasonable crop can be expected in four to five years.

The oldest coppiced " pocket " on the Old Station was treated in 1946 when 51 trees were coppiced. Unfortunately, 16 trees have since been lost through swollen shoot in this plot but the remaining 35 trees produced an average of 14 pods per coppiced tree this year.

REGENERATION OF CAPSID POCKETS—SQUARE MILE.

In July, 1950, an area of approximately one acre was coppiced. This area had been heavily damaged by capsids and was rapidly becoming a bad capsid pocket. Regeneration was rapid and the chupons are very healthy. Several of the most vigorous flowered in 1952, and on two a total of eight pods matured.

FOREST RESERVE CACAO PLOTS.

For the first time since these two plots were planted in the Pra Anum Forest Reserve in August, 1946, capsid damage has occurred extensively. These plots were chosen in an area remote from other cacao and for the first six years of their growth practically no evidence of capsid damage was seen. Capsid damage is common in mature cacao and occurs early in the life of young cacao in the cacao farms in this part of the Gold Coast. The growth of the cacao in the experimental plots has been rapid and the shoots such as would normally be most attractive to capsids. The long delay before initial infestation occurred undoubtedly points to established cacao being the main reservoir from which infestation comes to young cacao planted in the normal way in the midst of mature cacao.

JOHN NICOL.

R. K. OKRAH.

CHEMICAL CONTROL OF CAPSIDS.

D.D.T. dusts and cacao pollination.

A plot of young, healthy cacao remote from any other cacao has been dusted with 5 per cent. D.D.T. dust at three weekly intervals throughout the year. Power machines were used and all the trees were thoroughly dusted at each application. The initial dusting took place early in the year when few open flowers and set pods were to be found on the trees. As many as possible of those which were there were removed to ensure that the recorded yields were of pods pollinated after dusting.

Flowering was normal and as was expected the developing pods and trees showed practically no damage from capsids.

The 322 trees in the plot yielded 3,152 pods, an average of almost 10 per tree. This is a normal crop for trees of this age so that it

would appear that there has been no profound deleterious effect on the pollinating insects. Dusting will be continued for at least another twelve months.

Application of "Kumakate" to higher trees.

Trials were laid down to test out various chemicals and methods of applying them to trees which are too high to be treated by hand-brush. Such trees where the canopy has not closed up are very liable to damage and a method of control is urgently required.

Unfortunately, the area selected for the trials remained singularly free from capsids and capsid damage was sparse so that the figures obtained were too few to be significant. At the time of writing capsid numbers are increasing.

Spraying and dusting of Station Cacao.

A considerable amount of spraying and dusting of the Institute's cacao has been done during the year and one dusting machine has emerged from these operations as being considerably more efficient than any other so far tried. This machine, with a small motor, has a very well designed and efficient fan which throws the dust a long way. It appears to be fully capable of dealing with all but the tallest of the cacao trees found in the Gold Coast. Manufactured in Switzerland the machine, though expensive, certainly justifies further trials.

H. R. MAPOTHER.

JOHN NICOL.

IV. SOIL SCIENCE.

EFFECT OF PHOSPHATE ON BEARING CACAO.

Work on this experiment has been continued. The results of two years' harvests are shown in Table 1.

TABLE 1.

YIELD (PODS/TREE) IN PHOSPHATE FERTILIZER TRIAL.

Means of 1951/2 and 1952/3 harvests.

Fertilizer.	Rate of Application. (lbs./tree/annum).			Mean.
	0.0	0.5	1.0	
Rock Phosphate ...	18.6	21.1	12.0	17.2
Superphosphate ...	11.6	20.0 (± 4.00)	20.0	17.2 (± 2.31)
Double Superphosphate	16.3	18.0	16.4	16.9
	15.5	19.7 (± 2.31)	16.1	17.1

Taking these figures as they stand, there is clearly no significant effect. However, it has been shown that the total number of pods borne by trees is linearly related to the square of the girth (1). With the object of reducing error due to difference in tree size, analysis of covariance of yield on square of girth was carried out. The "corrected" results are shown in Table 2.

TABLE 2.

YIELD (PODS/TREE) IN PHOSPHATE FERTILIZER TRIAL
CORRECTED FOR DIFFERENCES IN TREE GIRTH.

Means of 1951/2 and 1952/3 harvests.

Fertilizer.	Rate of Application. (lbs /tree/annum).			Mean.
	0.0	0.5	1.0	
Rock Phosphate ...	20.7	19.8	13.0	17.8
Superphosphate ...	12.3	18.2	20.3	16.9
		(± 3.38)		(± 1.95)
Double Superphosphate	13.1	17.1	19.6	16.6
	15.5	19.7	16.1	17.1
		(± 1.95)		

Clearly, this correction has reduced the standard error but little, and no significant effects are shown. Similar results are obtained when the yield is expressed in terms of wet weight of cacao.

DISCUSSION.

It is not possible to say from these results that this particular area does not respond to phosphate. Experimental error is so large that, even after correcting for differences in tree size, a yield increase of 58 per cent. is required to be significant. Such a response is unlikely to be achieved in two years. Some sources of this large experimental error are considered below :—

(a) Large variations of yield between plots due, presumably, to local variations of soil fertility and moisture relations. For example, one 16-tree plot produced 422 pods during the 1952-3 season whilst another apparently healthy plot produced only 12.

(b) Losses due to black pod and squirrel damage amounted to only 8.6 per cent. of the total number of pods throughout the two years. Black pod losses were, however, concentrated on the lower lying areas and squirrel damage in the plots adjacent to bush. In the 1951-2 harvest, 32 per cent. of the pods in one plot were lost through these two causes. Thus, losses which, if evenly distributed throughout the experimental area would be of small importance, become major sources of error.

(1) Goodall, D. W., W.A.C.R.I. Ann. Rep. 1947-8, p. 70.

(c) Swollen shoot necessitated the removal of 43 trees (10 per cent. of the total in the experiment) during the two years. Again, these losses were concentrated in a few pockets.

As a result of these sources of error the experiments being carried out in these plots of mature cacao are to be discontinued.

UNIFORMITY TRIALS.

To provide suitable material for future manurial experiments, 4-acre sites for uniformity trials have been selected on W.A.C.R.I. and Department of Agriculture Stations. The location of these experiments is as follows:—

Eastern Province	...	W.A.C.R.I. (two plots).
”	”	... Bunsu.
”	”	... Oyoko (two acres only).
”	”	... Biene.
Western Province	...	Ayinasi.
”	”	... Buaku.
Ashantti	...	... Kwadaso.
”	...	... Juaso.
”	...	... Goaso.
”	...	... Bechem.
”	...	... Poanu.

Level areas of upland soil under secondary bush have been chosen on all stations and a wide variety of soil types and climatic conditions is covered. Unselected West African Amelonado will be planted as, in the absence of clonal material, it is believed to be the most uniform material available.

S. N. ADAMS.

V. CHEMISTRY.

CHEMICAL PROBLEMS RELATING TO CACAO SWOLLEN SHOOT VIRUS.

These have been defined in the 1951-2 Annual Report and are being studied in conjunction with the Plant Pathologists. Work has been concentrated on the development of a suitable technique for the qualitative and semi-quantitative examination of the amino acid and sugar content of healthy and diseased cacao tissues. Double one-dimensional paper chromatography has been found the most satisfactory procedure, especially when dealing with the large number of amino acids present in the leaf protein hydrolysates (>13).

This part of the work is nearing completion and is a necessary preliminary to similar analyses of tissue extracts from *T. cacao* and other hosts at differing stages of infectivity with strain 1A of cacao swollen shoot virus.

ANALYSES OF INSECT SECRETIONS.

A similar technique has been used to analyse the secretion obtained from *P. njalensis* feeding on healthy and diseased cacao tissues and will shortly be extended to secretion from *P. citri* and *Ferrisia virgata*, also known to be vectors of cacao swollen shoot virus. Results on secretion from diseased tissues are not available but thirteen amino-acids have so far been identified in *P. njalensis* secretion, not all of them being present in the feeding site.

Secretion from *Stictococcus sjostedii* feeding on *T. cacao* has also been examined. It is possible that differences in the chemical composition of this secretion and that of *P. njalensis* might supply evidence for the preference of *Crematogaster* ants for the latter, when *Stictococcus* secretion is much more readily available on the same host and the predominating sugar in both is sucrose. The only difference so far detected in the amino-acid composition of the two secretions is the presence of β -alanine in that of the *Stictococcus* sp. Evidence of other groups of compounds common to both secretions has also been obtained but these do not include any which could be considered an obvious attractant or repellent.

EXAMINATION OF CACAO BEANS FOR CHLOROGENIC ACID.

Chlorogenic acid is said to be widespread in nature and occurs in coffee beans, associated with a molecule of caffeine, to an extent varying from 5 per cent. to 8 per cent. of the dry bean. Its rôle in the plant kingdom is not known, but it has recently been suggested that it is a substrate for polyphenolase and that oxidative reactions formerly associated with tannins may, in fact, be due to chlorogenic acid. As the presence in cacao beans of a substance stable at temperatures up to 200° C. could have a bearing on certain aspects of assessment of flavour discussed in previous reports, attempts to identify and isolate this acid from cacao beans have been made.

Using a method which has been applied to its extraction from coffee, with minor modifications, followed by paper chromatography in *n*-butanol/acetic acid/water, an extract of defatted cacao beans gave two faint spots which fluoresced blue under U.V. light. One of these corresponded to a marker spot of authentic chlorogenic acid ($R_F = 0.60$) and turned green slowly in the presence of ammonia vapour. Further evidence of the presence of this acid in cacao beans is being sought before attempts to isolate it are made.

The second spot ($R_F = 0.75$) corresponded to a marker spot of caffeic acid, neither of which turned green in the presence of ammonia.

LABORATORY FERMENTATIONS AND ASSESSMENT OF FLAVOUR.

The oven-fermentation method for small samples of cacao described in previous reports, has been used during the past year chiefly for obtaining fully fermented samples of certain Upper

Amazon selections, chosen by the Plant Breeders. Ten-pod samples from nine selections were fermented under the optimum conditions for Upper Amazon cacao previously reported, and the sun-dried beans analysed for fat, alkaloids, F.F.A. total and protein nitrogen, moisture, and shell : bean ratio. The treatment was replicated three times and bulked Amelonado samples from the station harvest throughout the period were used as a standard. An abstract of the results is given in the following table of means. Full details will be published in due course :—

TABLE 3.

Constituent.	Nanay × ? T.15	Nanay × ? T.61	Nanay × Parinari T.79	Parinari × Nanay T.60	Parinari × Nanay T.76	Iquitos × Nanay T.85	Parinari × Iquitos T.65	Iquitos × ? T.17	Scavina × ? T.12	S.E.	W.A.A.
Per cent. Cacao fat	56.6	56.4	58.9	56.1	56.2	58.9	57.5	57.2	58.6	±0.70	57.4
Per cent. Theobromine ...	1.8	2.2	2.1	1.9	2.0	2.2	2.1	2.1	2.2	±0.11	2.4
Per cent. Caffeine...	0.4	0.4	0.3	0.3	0.2	0.4	0.4	0.4	0.16	±0.03	0.4
Shell/bean Ratio ...	0.16	0.14	0.16	0.15	0.16	0.15	0.16	0.14	0.16	±0.01	0.13

The effect of carrying out the early stages of oven-fermentation anaerobically is being studied, the products being assessed, in the first instance, by a local taste panel, using the method described in the 1951-52 Annual Report.

A Uniformity Trial of laboratory fermented samples has been done and the products submitted to American, British and local taste panels. Discussion of results is reserved until assessment by the British panel is available.

FACTORS AFFECTING VARIATION IN CACAO BEAN CONSTITUENTS.

Work is continuing on the effect of soil type, position of pod on tree, variation within and between cacao types and also seasonal effect. It will be extended to include age and environment in due course.

PUBLICATIONS.

1. Oil-bearing Seeds of Possible Economic Importance to West Africa. *Nature* **169**, 589-90, 1952.
2. Chemical Investigations on *Theobroma Cacao*. *Part I*—A Quantitative Study of Tannins and Tannin-like Substances in West African Amelonado. (In the Press.)
3. Chemical Investigations on *Theobroma Cacao*. *Part II*—Black-pod Disease in West African Amelonado. (In the Press.)

J. A. R. MACLEAN.

VI. PLANT PHYSIOLOGY AND HORTICULTURE.

VEGETATIVE PROPAGATION.

Routine Propagation.

Stem cuttings with two leaves are now employed for all routine propagation. Previous experimental work has shown that cuttings of this type produce larger root systems than the single-leaf type, and that the outgrowth of the axillary but is considerably quicker.

The wooden propagating frames previously described have continued to give satisfactory results. A saving in soil, baskets and labour has resulted from hardening the plants *in situ* before potting is carried out.

Clonal Nursery.

The first plantings of clones on this site were made about six weeks after the planting of the shade. Watering has been carried out as required, and the plants have grown rapidly since planting.

Some plantings were made during January, 1953, and these have established themselves well. Up to one foot of extension growth has been made over a period of six weeks, and there have been no losses.

The wet season is a time of possible nitrogen shortage in the soil, and during this time each plant received one-and-a-half ounces of sulphate of ammonia monthly. Although there is no quantitative evidence of its effect, the growth increment and the large size of the leaves on such young plants is remarkable in view of the poverty of the soil in which they are growing.

PHYSIOLOGICAL INVESTIGATIONS.

The Role of the Leaf in the Rooting of Single-Leaf Cuttings.

Ringling Experiments.

As described in a previous Report, mechanical ringling of the petiole of single-leaf cuttings had no effect on the weight changes in the cutting during the rooting period. The investigations reported here were aimed at the demonstration of possible effects of this treatment on the quantity of roots produced on cuttings so treated.

Three treatments were employed. In the first, the petiole was mechanically ringed: this has been shown to remove the tissues down to the ring of phloem fibres. In the second, all the living cells over an area of the petiole were killed with either chloroform or a jet of steam. The third received the normal cultural treatment and was used as a control. In all, a series of four experiments was carried out using a total of 720 cuttings. At the beginning and end of the experiments the length and breadth of each leaf was measured,

The results of these experiments showed that the effects of the ringing treatments were very variable, but that certain conclusions could be drawn from them. The steam treatment resulted in the almost complete defoliation of the cuttings during the first week to ten days in the propagators—presumably because of the starvation of the cuttings.

The chemical treatment depressed the amount of root produced, in terms of the number of primary roots and their total length, compared with those on the controls and those mechanically ringed. The most interesting result was that obtained with the mechanically ringed cuttings, which produced a greater quantity of roots than did the controls.

This suggests that some substance produced in the leaf has an inhibiting effect on the induction of root formation. This could be either a direct effect, or indirect by its effect on the naturally occurring growth substance responsible for the induction of root formation.

Investigation of the leaf fall in cuttings other than those steam ringed, showed that almost all abscission took place during the second and third weeks in the propagating bins. It was not extended generally over this period, but, according to the selection used, took place mainly over a period of two to three days. Starch tests of the stem portion of every cutting in which the leaf abscissed in response to light pressure of the finger, were negative in almost every case. Similar tests on cuttings which had not rooted at the end of one month, but which had retained their leaves, showed abundant starch present. It is evident that the fall of the leaf during the rooting period is due to the exhaustion of food reserves, and that the cutting does not fail because of the loss of the leaf.

The leaf measurements showed no variation during the time in the propagators.

Ringling Experiments Combined with the Supply of Additional Growth Substance.

A further series of five experiments was carried out on similar lines to those described above, but in these half the plants in each treatment received additional growth substance at the top of the stem portion, in the form of the naturally occurring indole—3—acetic acid. This was applied in a lanoline emulsion carrier.

The effects of the ringing treatment were essentially similar to those of the previous experiment. The application of the IAA produced a marked increase in the amount of root produced on all the ringing treatments, with the exception of those steam ringed, where apart from one experiment, all failed. This increase was so great, that in several of the experiments the chemically ringed plants receiving IAA produced more roots than the controls which did not receive it. The IAA also tended to even out the differences between

the plants which were mechanically ringed and those not mechanically ringed. The explanation of this may lie in a synergistic action between the IAA and the indole—3—butyric acid applied to the base of the cuttings, although the activity of the former in inducing root formation is so much lower than that of a number of synthetic growth substances that it is not normally used for propagation work.

Culture of Cambial Tissue of Cacao and Related Species in vitro.

During work on the factors involved in the rooting of cacao cuttings, attempts were made to induce the formation of roots on sections of stem grown in sterile culture on a nutrient medium. Although no differentiation of roots was obtained, a large mass of callus tissue was produced at the top of the stem. This suggested the possibility of using the culture of cambial tissue *in vitro* as a tool for the investigation of cacao metabolism and the behaviour of virus infected tissue.

Abundant growth of cambial tissue has been obtained on sterile bark explants taken from stems of any age. These are grown on a simple mineral medium containing sucrose, and solidified with agar. Growth of the new tissue is visible 24 hours after isolating the explant. After about one month *in vitro* portions of the new tissue can be isolated and grown as separate cultures, although the nutrient requirements in this case are more complex.

A spectacular increase in the growth of the sub-cultures occurs when they are grown on a medium consisting of coconut water only. In some cultures the growth increment has been fivefold in a month. This growth is of a pathological nature, differing greatly from that of the explants, which can be regarded as typical, and from that of sub-cultures grown on a synthetic medium, which is very similar to that of the explants. An account of this aspect of the problem is being published elsewhere.

Culture of Cambial Tissue from Virus Plants.

A number of experiments have been carried out with explants taken from virus infected plants, in the hope of finding differences in the growth pattern or histology compared with healthy explants. No difference was evident in the growth of the tissues. Several methods of vital staining were employed but no histological abnormalities could be detected.

At the same time, investigations on the persistence of Virus 1a in the explants were carried out in conjunction with the Pathologist. So far it has not been possible to demonstrate the presence of the virus in any of the cultures tested. Two possible causes of this lack of transmission are, firstly, that the tissue is unsuitable for mealybug feeding, and secondly, that the concentration of the virus in each explant is too low for the insects to pick it up.

J. F. ARCHIBALD,

VII. PLANT BREEDING.

ESTABLISHED TRIALS.

(a) *Progeny Trials*.—There has been a further increase in the yield of all selections in both the 1st P.T.A. and 2nd P.T.A. In both trials the selection E1 maintains its position as the highest yielder but compatibility tests on the parent clone show it to be self-sterile.

Four trees in the 1st P.T.A. and two in the 2nd P.T.A. have been removed with swollen shoot.

TABLE 4.

Area.	Selection.	Lbs. Dry Cocoa/Acre (Computed).
1st P.T.A. ...	E1	1170
	A196	777
	N38	744
2nd P.T.A. ...	E1	878
	TF1	797

(b) *Clonal Trials*.—All selections have now come into bearing and the yields from these two trials have increased considerably. Those stands pruned back in 1951 have now filled out and some are in bearing. The two Clonal Trials look most promising and are an indication of the possibilities of clonal plots.

TABLE 5.

Area.	Bearing Trees.	Number of Pods.	% Trees in Bearing.
1st Clonal 	914	7425	51
2nd Clonal 	496	2013	30

(c) *Introductions*.—Yields from the introductions have further increased but the rate of increase has fallen off.

The highest yielding hybrids are giving 1,450 lbs. dry cocoa/acre (computed from small plots).

Species.—During 1951–52, eight years from planting, several *Theobroma* species came into flowering for the first time. Pods obtained on *Th. grandiflorum*, *Th. speciosum*, and *Th. bicolor* by hand pollinations were used for virus and chemical tests.

An extensive programme of hybridisation of these species with *T. cacao* was carried out. Poor germination and seedling mortality, probably due to genetic unbalance, reduced the number of surviving hybrids.

(d) *Albino Plot*.—This plot of 36 trees at 10 ft. $\times$ 10 ft. spacing has yielded its first large crop. It was laid down to study the distance covered by pollinating insects and first figures indicate that trees are pollinated one in six times by pollen from trees 30 feet away.

BREEDING PROGRAMME.

(1) A considerable number of hand-pollinations have been made during the year in connection with the cytological problems under study. The bulk of these pollinations have been concerned with the elucidation of the breeding system in the several types of *Th. cacao* both local and recently introduced.

(2) The 8th P.T.A. was planted in June, 1952. Details of this trial appear in the 1951/52 Annual Report. From height and girth measurements the crosses (Local types $\times$ Upper Amazon) have proved significantly more vigorous than the local types and certain of the introduced types. Establishment of the trial has been good.

(3) The Department of Agriculture, Gold Coast, is planting a series of one-acre variety trials adjacent to the four-acre uniformity trials laid down by the Soil Chemist. All the beans for the one-acre variety trials are to be derived from hand-pollinated pods. It is hoped to compare the performance of Introduced and Local selections in relation to soil and climatic conditions.

(4) The Department of Agriculture, Gold Coast, has reported on a number of unusual cacao types and useful material has been collected for cytological and genetical studies.

(5) During the year consignments of beans from hand-pollinated pods have been sent to Sierra Leone and Nyasaland. The Department of Agriculture, Gold Coast, has received over 9,000 pods both open and hand-pollinated.

R. KNIGHT.

H. H. ROGERS.

VIII. MYCOLOGY.

BLACK POD DISEASE.

A new programme of work was started in August, 1952. The Pod Disease Classification and the Control Spraying Experiments have been concluded.

AIRBORNE DISSEMINATION OF THE DISEASE.

Little is known about any diurnal or seasonal phases of the distribution of black pod. Information on the times of spread would be invaluable in the compilation of economic spraying schedules.

A study of the airborne distribution of spores of *Phytophthora palmivora* Butl., was begun at the beginning of the dry season. A Casella Cascade Impactor was used to take air samples.

Several sticky preparations for coating glass slides were tried: Vaseline, Glycerine, "Ostico" and Wood Resin mixed with castor oil and dissolved in various solvents. The mixture used finally was two parts of castor oil and one part wood resin dissolved in Toluene.

In test runs performed in the laboratory, directing a stream of air over diseased pods towards the impactor, heavy mixed spore deposits were collected on the slides but no spores of *P. palmivora* were trapped.

Operations under cacao in the field during the dry season have failed to catch any spores of the fungus.

SURVIVAL OF *P. palmivora* DURING THE DRY SEASON.

Studies on the saprophytic existence of *P. palmivora* in cacao soil were started in December, 1952, to find out if the soil is a source of disease infection during the dry season.

Large green pods were buried in sterilised soil which had been previously inoculated with the mycelium and spores of *P. palmivora*; after four to six days all pods contracted the disease.

The fungus was isolated from husk heaps and soil in the field. The above method of burying healthy pods was used. Three pods out of six were diseased after burial in husk heaps for five to eight days. Of thirty-nine pods buried in soil on G73 plot, W.A.C.R.I., twelve had black pod after six to ten days.

Eight metre square plots on different soil types were selected, six on W.A.C.R.I. and two on Department of Agriculture plots at Bunsu. Every month five pods are buried in each plot, removed after eight days and isolations made from any diseased tissue for identification. *P. palmivora* was not recorded in these soil plots in January and February, 1953.

An investigation of other methods used for isolating fungi from soils has started.

A. L. WHARTON.

IX. MEALYBUG STUDIES.

Coccid Collections.

Collections of some of the less common mealybug species have been made with a view to rearing them in sufficient numbers for virus vector tests in collaboration with the Division of Plant Pathology. During this work *Planococcus kenyae* Le Pelley, and a species of *Pseudococcus* near *P. proteae* Hall, were recorded for the first time from the Gold Coast.

Several other species new to the W.A.C.R.I. collection have been obtained but the majority of these were from monocotyledons and would not feed on cacao.

Pseudococcus sp. ?*comstocki* was found in small numbers on potatoes imported from Madeira. Attempts to rear it on potato sprouts and cacao at Tafo were not successful.

BIOLOGICAL CONTROL OF COCCIDAE.

Natural Enemies.

The collection of local parasites and predators has continued and specimens of several species new to the W.A.C.R.I. collection have been sent to the Commonwealth Institute of Entomology for determination.

INTRODUCTION OF EXOTIC PARASITES.

During the year twelve species of exotic parasites have been received from the Commonwealth Bureau of Biological Control in California and two species from *Ferrisia virgata* (Ckll.) have been received from the Bureau's sub-station in Trinidad. These are all tested against the indigenous mealybug vectors and, if successful, they are bred up or imported in large numbers for liberation in selected areas.

In all 208,546 parasites have been released.

TABLE 6.

RELEASES OF IMPORTED MEALYBUG PARASITES.

<i>Species.</i>	<i>Number Released.</i>		
<i>Pseudaphycus angelicus</i> ...	...	...	41,385
<i>Pseudophycus mundus</i> Gahan ...	...	...	134,520
<i>Pauridia peregrina</i> Timb. ...	...	...	16,276
<i>Leptomastix dactylopii</i> How. ...	...	...	4,910
<i>Blepyrus saccharicola</i> Gahan ...	...	...	6,921
<i>Allotropa</i> sp. ...	...	...	4,534

No introduced parasites have been recovered during the year but twenty-two specimens of a predaceous Coccinellid believed to be *Euxochomus flavipes* were collected from an infestation of *Ferrisia virgata* (Ckll.) in October and November, 1952. Specimens have been sent to the C.I.E. for determination. Should these insects prove to be *E. flavipes* it will be the first record of the recovery of this species since its introduction and liberation in September, 1949.

R. G. DONALD.

PARASITE HOST PREFERENCE TESTS.

Following the successful mass-rearing of *Pseudaphycus angelicus* on the pine-apple mealybug (*Pseudococcus brevipes*) a series of host preference tests has been conducted to ascertain whether the parasite will readily reproduce in *P. njalensis* in the presence of *P. brevipes*.

The main object was to examine the possibility of creating a reservoir of the parasite on *P. brevipes* infesting pine-apples growing in the release areas. Such a reservoir would serve as a source of supply from which the parasite could invade *P. njalensis* colonies on cacao.

The results obtained suggest that the parasite might show a preference for *P. brevipes* under natural conditions, although the fact that *P. njalensis* cannot endure starvation for a long period, might have been responsible for the low rate of parasitism of that species. The average rate of reproduction in the tests worked out at 1.5 adult parasites per one *P. brevipes* and .02 per *P. njalensis*.

ANT ATTRACTANT TESTS.

The ant-mealybug association is well-known and it plays an important part in the spread of the cacao swollen shoot virus. As a preliminary to the development of a poison-bait for the control of mealybug-tending ants, a series of experiments has been started to compare the attractiveness of various substances to ant species of the genera *Pheidole* and *Crematogaster* which are usually associated with mealybugs in the field. The tests have included also some on *Oecophylla longinoda*, an ant which is normally scale-tending, to see its response to the substances tested against the ants associated with mealybugs.

Four sets of comparative tests, using honeydew and other materials such as live and dead mealybug and scale-insect colonies and simple sugar solution, have been carried out but owing to the capricious behaviour of the ants the results have been inconclusive. It is hoped that the analysis of mealybug and scale-insect secretions being done by the Division of Chemistry will enable future tests to be carried out more successfully.

F. E. DECKER.

GROUND MIGRATION OF MEALYBUGS.

The accepted control for the cacao swollen shoot virus is to cut out and pile the infected trees. In this connection investigations were made in the laboratory, in the insectary and in the field into the possible migration of mealybugs from cut cacao to healthy trees.

It is too early to draw definite conclusions from the work so far carried out, but preliminary experiments in the laboratory confirmed previous opinion that the early nymphal stages more readily migrate than the later instars. The number of mealybugs which migrated from cut cacao shoots over soil was found to be less than 6 per cent. of the number which migrated under the same conditions over a smooth migration surface. It was also shown that the retarding effect of soil was greater for the early nymphal stages than for the older mealybugs. Investigations were commenced into the role played by ants in mealybug migration but inconclusive results have so far been obtained.

Preliminary observations on the behaviour of mealybugs in slash piles made from felled trees showed that migration from the piles occurred to a very limited extent. The number of mealybugs recorded within 15 feet of the edges of six slash piles during the first two weeks after their formation was less than .07 per cent. of the estimated pile population. Not one of 400 cacao seedlings became infected with the virus during the first two weeks when placed within 9 feet of three slash piles of mealybug-infested trees which were infected with cacao swollen shoot virus. The placing of cut wood supporting about 7,000 mealybugs at a distance of 3 feet from each of 14 trees inoculated with associated ants did not significantly increase the mealybug population on the trees after a period of three weeks.

The practice of piling infected slash is one which affords shelter to the majority of mealybugs on the cut wood. Preliminary experiments to ascertain the effect of climatic factors on ant tents and mealybugs on cut cacao suggest that sheltered conditions tend to encourage the persistence of mealybugs and carton coverings. Mealybug colonies have been recorded in slash piles for as long as seven to nine weeks after their formation.

“ LABELLED ” MEALYBUGS.

In connection with migration studies, investigations were carried out into the feeding of mealybugs on plants and artificial media containing various dyes. Although coloured mealybugs were obtained, the techniques employed were not suitable for practical application. Latterly, mealybug infested plants have been cultured in a solution containing radio-active phosphorus in the form of orthophosphoric acid. Radio-active mealybugs have been obtained and are being used in migration experiments.

P. B. CORNWELL.

SYSTEMIC INSECTICIDES.

The method of screening “ systemic ” insecticides described in the previous Report has continued in use.

Several chemicals and formulations have been received from manufacturers for examination and all have been screened and tested against *Pseudococcus njalensis*, the commonest vector of cacao swollen shoot virus. Further tests were made by soil applications of the chemicals around the base of mature trees. These tests have shown that dimetox ((bis-dimethylamino) fluorophosphine oxide) and products containing a high proportion of it, still remains the most effective systemic insecticide against *P. njalensis*.

Further work with a commercial product containing Schradan (Octamethylpyrophosphoramidate) has confirmed previous results that only at very high concentrations has this chemical any effect on the mealybugs and even at such concentrations the effect is slight and the action irregular.

It has been found during screening tests with seedlings that some plants give anomalous results and show high numbers of mealybugs remaining alive whereas other plants in the same series are clear, or almost clear, of insects. Such irregularities have also been noted when mature trees have been treated by soil application of the insecticide. The seedlings are grown in soil and it was thought that this method of culture might in some way account for such discrepancies.

Comparative trials were therefore laid down using seedlings growing in soil and seedlings growing in washed sand. Samples of pure dimefox and two other insecticides, both containing dimefox, were available and these were used in the trials. On examination it was found that there was little difference in effectiveness of the pure dimefox whether in soil or in sand. With the other two formulations, however, the results obtained from the plants growing in soil were much less good than those obtained from the plants growing in sand. Several of the plants in soil showed the same lack, or near lack, of toxic action which has been noticed in previous tests.

Systemic insecticides and mealybugs infesting cacao pods.

In several field trials there were indications that dimefox, and insecticides containing it, were less effective against mealybugs infesting pods than against those on vegetative parts of the tree.

An experiment was laid down in which considerable numbers of young pods on mature trees were infested with *P. njalensis* by placing mealybug colonies and ant nests near the pods. As the twigs on which the colonies were established dried out, the mealybugs moved or were moved by the ants to the nearby pods. These assisted migrations were successful and a sufficient number of pods became infested.

Half the number of trees bearing pods thus infested were treated by soil application with a solution containing 5 per cent. dimefox, the others remaining untreated as controls. After six weeks all the pods were cut off and counts made of the surviving mealybugs. Healthy and active colonies of mealybugs were found on many of the pods from treated trees so that it would appear that soil treatment with dimefox is not effective in eliminating mealybugs established on the surface of pods.

H. R. MAPOTHER.
JOHN NICOL.

X. AGRONOMY.

A. SUB-STATIONS.

The progress of the cacao on all sub-stations has been good, the exception being that at Akwadum planted at the wider spacings on sandy soil where the trees have not formed a canopy and have been severely damaged by capsid.

The problem of capsid control has become more difficult of solution as the trees have grown beyond the reach of the hand application of D.D.T. emulsion.

Even on those areas of well-established cacao where a complete canopy has been formed new growth continues to extrude above the existing canopy level and provides ideal feeding and breeding conditions for the bugs. Such growth is extremely difficult to reach even with dusting equipment.

The incidence of swollen shoot disease has been extremely low and is shown in the following Table:—

TABLE 7.

Sub-station.	Number.	Remarks.
Akwadum	8	Contiguous to or on the Resistance Trial Area.
Adownkwanta ...	1	Control Plot.
Nankese	Nil	
Kukua	11	1 in Control Plot, 10 in Treated Plot.
Koransang	10 20 6	Mature trees. Coppiced trees. Seedlings.

On the three more advanced farms at Koransang, Kukua and Nankese the yields in pods from selected areas were recorded, the cacao being seven years of age.

TABLE 8.

Sub-station.	Acreage of selected plots.	Yield in pods.	Estimated yield dry cacao per acre.
Koransang	3.0	3810	106 lbs.
Kukua	5.0	7385	123 lbs.
Nankese	3.5	3621	86 lbs.

Four acres of land at Akwadum, where attempts to establish West African Amelonado cacao because of drying of the sandy soil in the dry season, were planted with well-grown Upper Amazon seedlings in baskets in June. All seedlings survived the dry season.

The thinning of the cacao at sub-stations has presented a difficult problem, as the cacao was planted at a nominal 5 ft. $\times$ 5 ft. in lines following the contours. Regular thinning has, therefore, been impracticable. It has been decided to remove the weaker trees as they become suppressed by their stronger neighbours, thus avoiding any drastic opening up of the canopy.

B. OLD STATION.

Established Cacao.

The Minor Crop began in June and ended in August. The total yield in pods was 46,646 as compared with 13,569 of the corresponding period last year.

The Major Crop began in September and terminated in January. The total weight of marketable cacao for the Minor/Major Crops was 18.2 tons. Pods supplied as seed to the Department of Agriculture totalled 83,358; the assessed dry weight of the pods issued, taking 11.2 pods to the lb. dry, was 3.32 tons; the overall total, therefore, of marketable cacao was 21.52 tons as compared with 23.75 tons produced last year.

Systematic and weekly harvesting was carried out to reduce incidence of black pod disease.

Off-season harvesting began soon after the end of the Major Crop, the pods being used as seed.

TABLE 9.
MINOR/MAJOR CROP YIELDS, 1938-52.

Season.	No. of pods harvested.	Per cent. of pods discarded.	Total wt. of wet Beans.	Per cent. dry to wet wt. beans.	Pods per lb. dry.	Yield per Acre dry cacao in lbs.
1938-39 ...	775,065	15.8	127,468	43.8	11.7	808
1939-40 ...	716,487	11.7	132,627	40.8	11.7	783
1940-41 ...	706,443	8.4	140,161	41.4	11.1	788
1941-42 ...	767,461	13.3	139,882	40.0	11.9	795
1942-43 ...	621,724	10.5	115,388	43.1	11.1	749
1943-44 ...	643,180	16.4	113,995	40.4	11.7	720
1944-45 ...	593,217	14.7	108,037	40.8	11.5	689
1945-46 ...	547,762	29.2	76,658	40.9	12.4	492
1946-47 ...	368,859	5.5	58,564	44.5	13.0	409
1947-48 ...	355,480	16.4	63,547	40.1	11.6	400
1948-49 ...	488,313	5.5	98,710	42.4	11.0	656
1949-50 ...	451,088	7.4	93,957	38.5	11.1	568
1950-51 ...	452,677	3.4	87,800	41.3	11.6	369
1951-52 ...	469,697	2.5	99,183	40.7	11.3	633
1952-53 ...	389,752	5.2	82,341	40.0	11.2	518
15-Year Mean	555,817	11.7	102,555	41.2	11.7	638

TABLE 10 (a)—LIGHT CROP.

Delivery of Crop from 57.94 Acres.

Crop.	Date of picking.	No. of pods harvested.	Per cent. pods discarded.	Wet wt. of beans lbs.	Per cent. dry to wet.	Ave. yield (lb.) per acre dry cacao.
Minor	June 18-21	1,936	8.1	432.7	37.74	2.8
	„ 25-July 1	1,620	5.6	122.4	39.17	0.8
	July 7-10	4,116	4.5	1041.6	38.45	6.9
	„ 22-28	11,237	4.2	2842.5	39.19	19.2
	Aug. 6- 9	11,481	4.1	2878.7	37.73	18.7
	„ 12-16	10,963	7.7	2727.2	40.83	19.2
	„ 18-20	5,293	4.3	1326.1	37.01	8.5
Total ...	June-August	46,646	5.2	11371.2	38.83	76.1

TABLE 10 (b)—MAIN CROP.

Delivery of Crop from 57.94 Acres.

Crop.	Date of picking.	No. of pods harvested.	Per cent. pods discarded.	Wet wt. of beans lbs.	Per cent. dry to wet.	Ave. yield (lb.) per acre dry cacao.
Major	Sept. 1- 8	28,539	4.8	6455.4	39.78	44.3
	„ 12-19	32,590	5.5	7201.4	40.97	50.9
	„ 22-30	41,550	5.8	8855.9	40.63	62.1
	Oct. 3-14	54,947	6.2	1144.8	40.10	79.2
	„ 17-28	37,998	4.5	7807.8	40.41	54.5
	„ 29-Nov. 7	27,731	4.4	5690.9	41.49	40.8
	Nov. 11-25	36,257	3.9	7370.9	41.50	52.8
	Dec. 2-13	26,946	4.8	4526.3	46.23	36.1
	„ 18-30	18,333	3.8	3078.0	45.72	24.3
	Jan. 2- 9	10,398	7.4	1671.5	42.71	12.3
	„ 12-16	3,297	11.0	549.5	43.18	4.1
Total Major	Sept.-Jan.	318,586	5.2	64655.4	41.35	461.4
Total Crop	June-Jan.	365,232	5.2	76026.6	40.97	537.5

TABLE 11 (a)—DELIVERY OF CROP.
1952-53.

Crop.	Date of picking.	No. of pods Har-vested.	Per cent. pods dis-carded.	Wet wt. of beans lbs.	Per cent. dry to wet.	Ave. yield (lb.) per acre dry cacao.
	1952					
Minor ...	June 18-Aug. 20	46,646	5.2	11371.2	38.83	76.1
Main ...	Sept. 1-Jan. 16	318,586	5.2	64655.4	41.35	461.4
Total ...	June-Jan.	365,232	5.2	76026.6	40.97	537.5

TABLE 11 (b)—DELIVERY OF CROP.
1951-52.

	1951					
Minor ...	May 15-Aug. 11	13,569	—	—	—	20.0
Main ...	Aug. 16-Jan. 30	424,205	2.5	82883.8	40.78	626.7
Total ...	May-Jan.	437,774	2.5	82883.8	40.78	646.7

The distribution of yields on the recorded plots (56 acres) in 50 lbs. class intervals or 200 lbs. per acre is shown in Table 12.

TABLE 12.
DISTRIBUTION OF PLOTS YIELDS ON 224 $\frac{1}{4}$ -ACRE PLOTS.
1952-53.

Yield Class.	Percentage of Total Number of Plots in each class.				
	1948/49.	1949/50.	1950/51.	1951/52.	1952/53.
0- 200	5.36	5.80	4.91	4.46	5.80
201- 400	13.84	20.09	20.09	13.84	28.13
401- 600	24.11	30.36	34.38	25.89	29.91
601- 800	24.55	25.00	22.77	30.36	23.66
801-1000	18.30	16.07	12.05	16.52	10.27
1001-1200	8.93	2.23	4.46	7.14	2.23
1201-1400	4.46	0.45	1.34	1.34	—
1401-1600	0.45	—	—	0.45	—
Highest Plot Yield in lb. per acre ...	1485.60	1252.84	1381.32	1461.32	1103.88
Lowest Plot Yield in lb. per acre ...	3.68	1.64	8.64	—	—

There has been a fall in the modal class from 601-800 lbs. per acre in 1951/52 to 401-600 lbs. per acre in 1952/53.

Loss of Trees.

The number of trees lost through diseases, old age and accident was 620.

A. SQUARE MILE.

Established Cacao.

The total dry weight of cacao from the Square Mile was 12 tons (including calculated dry weight of beans from pods used as seed). The total yield was 80 per cent. of the previous year's crop.

Routine maintenance work including selective brushing, the removal of loranthus and re-inspection and re-treatment of swollen shoot disease continued regularly in all areas.

B. STATION MAINTENANCE AND GENERAL.

Cacao.

Removal of backward cacao seedlings in the young seedling areas in the Uniformity Trial was carried out. Some advanced plants have come into bearing. A final thinning will be necessary before the plants are ticketed.

As a prophylactic against capsid ravages all seedlings were periodically hand-painted with D.D.T. emulsion. The result has been excellent.

Regeneration work, involving the earthing up of basal chupons of less than four inches from ground level on old trees, and the planting of basket seedlings in gaps caused by the removal of diseased trees, continued in the Uniformity Trial Area. A total of 7,055 chupons has been recorded: of the selected chupons 1,073 have come into bearing, cushioning the fall in yield of the senile parent plants.

All chupons were regularly painted with D.D.T. emulsion.

363 stumped forest tree seedlings of various species were planted in exposed places in the Uniformity Trial. Growth has been most satisfactory.

Selective weeding, routine pruning, removal of mistletoe, and regular inspection of the cacao trees were carried out in all areas.

Seven acres of land on the Southern Half of the Old Station were put under cacao cultivation in the normal routine planting programme.

Nurseries.

Stocks of forest trees and ornamental and hedge plants have been kept in the Horticultural Nursery. From the Cacao Nursery

3,102 West African Amelonado cacao seedlings were issued for experimental and planting purposes. Further stocks of 2,600 seedlings of Amelonado and 2,660 of Amazon Type cacao have been kept in baskets.

Food Crops.

Maize, Chinese yams, groundnuts, soya beans and rice were planted on land unsuited to cacao cultivation.

5,086 lbs. of fresh vegetables were produced; the yield shows an increase of 27 per cent. over last year's production.

General.

Routine anti-malarial measures continued in the Residential Area and in W.A.C.R.I. village. Roads and drains were kept in a good state of repair and hedges and compounds were maintained.

S. E. NTIM KWAFO.

C. TRANSPLANTING EXPERIMENTS.

There are now four experiments in the field to investigate ways of handling bare root cacao seedlings to ensure maximum survival after transplanting from nursery beds. The first three experiments were laid down in 1951 and the mean accumulated percentage losses after two dry seasons in the field are shown in the accompanying table. Two factors were investigated in these experiments; firstly, the application of superphosphate at the rate of one ounce per square yard of nursery bed, and secondly, three treatments at the time of transplanting, namely, (a) stumping to 4 in., (b) removal of leaves and (c) untreated. No effect from the phosphate treatment has ever been demonstrated and the values shown in the table in experiments T.E. I and II are averaged over phosphate and no phosphate. Angular transformation was used in analysing the results.

The figures confirm the previous year's findings in that with careful hand-fork lifting which was used in T.E. I and II no form of stem treatment produces any advantage over the controls, and, in fact, stumping appears to be disadvantageous.

TABLE 13.

Experiment No.		Treatment means.			S.E.
		Stem Whole.	Leaves Removed.	Stumped to 4 in.	
T.E. I ...	Angles Per cent.	24.0 16.5	29.1 23.7	33.6 30.7	± 2.04
T.E. II ...	Angles Per cent.	20.8 12.6	31.6 22.8	43.1 46.7	± 2.41
T.E. III ...	Angles Per cent.	68.0 86.0	41.2 43.4	44.7 50.0	± 2.41

Another experiment was laid down during the year to determine the optimum age at which to transplant bare root seedlings. Sowings of beans in nursery beds were made at regular intervals during the main crop season to produce seedlings of approximately 8, 7, 6, 5 and 4 months of age at the time of optimum field conditions for transplanting, that is during the early rains in May and June. The experiment was also designed to examine further the comparison of hand-pulling and careful forking from the nursery beds both with and without the removal of leaves at the time of transplanting. The plants have now passed their first dry season in the field and it would appear that the percentage survival to this stage is dependent neither on the age of the seedling at the time of transplanting, nor whether or not the leaves were removed at the time. What is of great importance, however, is the value of careful hand-fork lifting from the nursery beds. With hand-pulling mean percentage losses were 61 per cent., but with hand-fork lifting they were as low as 25 per cent. This result should be compared with those shown in the preceding table for the "Stem Whole" and "Leaves Removed" treatments where T.E. I and T.E. II also show low order losses consequent upon careful lifting and T.E. III shows high order losses consequent upon hand-pulling.

YIELD AND GROWTH STUDIES.

1. A study is being made of the accumulated records of the quarter-acre plots on the Institute's land which have been individually tree recorded since the 1938/39 crop. The following table shows in terms of quartiles of total tree population when arranged in order of merit, their percentage contribution to the total yield:—

Quartile.					Contribution to total yield.
First	...	...	...	...	6.0 per cent.
Second	...	...	...	...	16.8 " "
Third	...	...	...	...	27.8 " "
Fourth	...	...	...	...	49.4 " "

Hence 75 per cent. of the trees are responsible for 94 per cent. of the yield. The remaining 25 per cent. of poor bearers are being examined in the field to determine, if possible, any obvious reasons for their poor performance such as excessive capsid damage, high black pod incidence or other ecological factors.

The analysis by quartiles follows the general picture shown by the yield histogram and frequency curve which is of typical J-shape.

2. Data has been accumulated over the past year with a view of finding an equation to show the relationship between the girth of a cacao tree and its live-weight. An estimate of known reliability of the weight of a standing cacao tree is required in experimental and routine work with systemic insecticides where dosages are worked out in terms of "parts per million weight for weight".

An exponential relationship was finally established here and the Institute is indebted to workers in the Statistics Department of Rothamsted Experimental Station for its confirmation. The relationship is of the form $\log_{10} w = b \log_{10} g - a$, where w is the estimated weight in pounds and g is the girth in inches, a and b being constants. Despite the fact that a good fit was obtained even the 5 per cent. confidence limits remain very wide. More observations are being made.

3. Recording of the plots described in previous Annual Reports (1951/52) to determine the performance of mature cacao trees on a selection of soil types represented at W.A.C.R.I. and on other plots as a beginning in an attempt to forecast cacao yields by the use of small sample plots has proceeded but results of statistical analyses are not available at present.

4. An analysis of results from the Upper Amazon Spacing Trial has been carried out, and the following table shows the yields converted to pounds of dry cacao per acre produced under the various treatments by four-year-old seedlings.

TABLE 14.

Spacing.			8 ft. × 8 ft.	10 ft. × 10 ft.	12 ft. × 12 ft.
Unpruned* plots	...	...	21.4	34.5	10.3
Pruned* plots	...	...	37.5	21.8	18.6

No significant differences were demonstrated, but the table is presented for general interest.

CACAO FERMENTATION AND QUALITY EXAMINATION.

In the main, attention has been drawn away from experimental work in cacao fermentation and has been concentrated on the examination of changes in the purple bean content of cured cacao when left in store for a period of time. Earlier observations had indicated that there was a gradual drop in the purple bean percentage from initial counts on completion of drying to six to eight months afterwards. Consequently a 4-lb. sample has been withdrawn from all cured cacao produced from the Institute's land, these samples being examined at eight-weekly intervals and the purple bean content noted. Downward trends are becoming apparent but the experiment will not reach its conclusion until much later in the year.

Similarly, cacao prepared from pods supplied by the Institute and the Department of Agriculture from Upper Amazon plots, has been stored and parallel observations made.

* Pruning implies that the plants have been restricted in growth to their first whorl of fan branches, all subsequent chupons having been removed.

FLAVOUR ASSESSMENT OF CACAO PREPARED FROM THE 1951/52 MAIN CROP.

As previously reported (Annual Report, W.A.C.R.I., 1952) samples of cured cacao from the various Upper Amazon and Gold Coast Selections were prepared and submitted for flavour assessment to the British Food Manufacturing Industries Research Association, Walter Baker Chocolate Division of the General Foods Corporation, and to a local taste panel composed of members of the staff of the Institute.

The General Foods Corporation have supplied sets of numerical scores indicating the values of each type when examined as either a base or flavour cacao by the member firms taking part in the test. In general it may be stated that none of the firms showed any marked objection to any of the new types when evaluated as base cacaos. Overall appraisal by the panel as a whole is of rather limited value because of differing orders of precedence given by different manufacturers, and rank correlation analysis has indicated very low measures of agreement between participating firms.

The local taste panel members carried out their evaluations during the year, and it had been hoped that it would have been possible to compare their findings with those of the expert panel of the B.F.M.I.R.A. This would have been a means of calibrating the discriminatory powers of the members of the local panel as well as defining the value of the various cacao types. Unfortunately, to date, lack of information from the B.F.M.I.R.A. panel has prevented this, and it also now appears that the expert panel are for various reasons unable to use a prototype schedule of marking (referred to by the Chemist in his report for 1951/52) on which the local panel based their marking.

R. WICKENS.

APPENDIX I.

METEOROLOGY—SUB-STATIONS.

RAINFALL IN INCHES—1952.

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Akwadum ...	0.49	2.24	8.56	2.76	5.87	8.95	2.11	2.03	11.55	6.99	3.1	1.79	56.44
Nankese ...	0.54	2.07	12.73	1.71	5.19	10.51	2.64	1.04	10.06	4.90	4.44	2.12	57.95
Koransang ...	—	4.08	5.77	4.88	8.63	9.97	1.26	.98	6.82	6.38	6.56	4.95	60.28
Kukua ...	—	1.32	5.21	4.03	7.07	9.94	1.13	.25	4.34	8.66	6.10	3.32	51.37
Adownkwanta	1.21	3.22	11.25	4.68	7.45	16.51	7.70	1.94	6.67	11.84	2.80	.74	76.01

ANNUAL RAINFALL COMPARED WITH PREVIOUS YEARS.

Year.	Akwadum.	Nankese.	Koransang.	Kukua.	Adownkwanta.
1950	47.80	57.01	48.21	42.08	60.79
1951	78.82	59.66	73.20	60.67	69.40
1952	56.44	57.95	60.28	51.37	76.01

METEOROLOGICAL DATA, W.A.C.R.I.

(a) FIGURES FOR 1952 COMPARED WITH 15-YEAR MEANS.

	Jan.	Feb.	March.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Highest Shade Maximum 14-year mean	91.4	93.7	93.5	93.7	92.1	89.3	86.8	86.4	88.0	89.8	90.5	90.6
" " 1952... ..	92	94	94	98	93	88	87	89	88	89	91	91
Lowest Shade Minimum 14-year mean	59.1	61.2	65.8	66.1	66.6	66.1	66.2	65.0	66.6	66.3	65.0	62.7
" " 1952... ..	61	58	65	68	67	63	58	55	69	62	63	62
Mean Relative Humidity 14-year mean	85.9	83.7	81.6	80.5	81.7	84.7	86.0	85.9	85.1	83.1	81.8	84.2
(9.00 G.M.T.)												
Mean Relative Humidity 1952... ..	85.5	82.3	82.6	70.7	79.8	86.9	88.7	88.5	89.8	85.0	83.4	87.0
(9.00 G.M.T.)												
Mean Relative Humidity 14-year mean	54.1	51.3	54.7	57.9	62.3	67.9	68.9	61.3	70.6	69.8	65.4	61.4
(3.00 G.M.T.)												
Mean Relative Humidity 1952... ..	62.3	59.7	61.5	61.2	69.4	79.2	76.5	78.8	71.2	73.4	67.9	67.0
(3.00 G.M.T.)												
Rainfall in inches 14-year mean	1.56	3.63	6.09	5.80	7.07	8.33	5.53	2.79	6.23	8.65	5.08	2.44
" " 1952	2.00	1.52	10.39	5.44	5.95	9.34	4.07	2.84	11.51	10.18	1.70	0.83
Number of wet days 14-year mean	3.4	7.3	11.6	11.2	13.4	18.4	13.4	12.8	13.9	18.0	11.0	5.0
" " 1952	3	7	12	11	12	20	16	9	19	20	8	3

(b) ANNUAL RAINFALL FIGURES, 1938-52.

1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	15-year mean.
55.33	84.96	56.92	56.59	59.45	69.09	49.12	68.87	47.03	67.30	66.99	71.81	63.47	63.23	65.77	63.20

(c) MONTHLY RAINFALL (IN INCHES) AND NUMBER OF WET DAYS—APRIL, 1952—MARCH, 1953.

Month.	1952 Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1953 Jan.	Feb.	March.
Rainfall in inches ...	5.44	5.95	9.34	4.07	2.84	11.51	10.18	1.70	0.83	1.48	4.11	4.78
Number of wet days ...	11	12	20	16	9	19	20	8	3	3	4	14

APPENDIX II.

PUBLICATIONS.

- MACLEAN, J. A. R. ... Oil-bearing Seeds of Possible Economic Importance to West Africa. *Nature* **169**, 589-90, 1952.
- MACLEAN, J. A. R. ... Chemical Investigations on *Theobroma Cacao*. *Part I*—A Quantitative Study of Tannins and Tannin-like Substances in West African Amelonado. (In the Press.)
- MACLEAN, J. A. R. ... Chemical Investigations on *Theobroma Cacao*. *Part II*—Black-pod Disease in West African Amelonado. (In the Press.)

WEST AFRICAN CACAO RESEARCH INSTITUTE.

PUBLICATIONS.

ANNUAL REPORT, April, 1951, to March, 1952 : Published by the Crown Agents for the Colonies. (In the Press.)

QUARTERLY REPORTS—Cyclostyled :

Twenty-sixth Quarterly Report, April to June, 1952.

Twenty-seventh Quarterly Report, July to September, 1952.

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Twenty-ninth Quarterly Report, January to March, 1953.

